THE

JOURNAL OF GEOLOGY

SEPTEMBER–OCTOBER, 1900

THE ORIGIN OF BEACH CUSPS

In the April-May 1900 number of this JOURNAL, p. 237, Mark S. W. Jefferson has an interesting article upon "Beach Cusps.' I have often noticed these peculiar beach forms and was for some time puzzled to know how they were produced. The explanation offered by Mr. Jefferson for those on the Lynn Beach, Massachusetts, is that they "must be ascribed to the agency of the seaweed piled up on the beach, modifying the action of the greater waves." The attention I have been able to give the subject leads me to the conclusion that beach cusps are formed by the interference of two sets of waves of translation upon the beach. I know of no peculiarities of these cusps that are not explained by this theory of their origin. It will be understood by reference to the accompanying diagram, Fig. 1. The concentric lines represent two sets of waves advancing on the beach in the directions indicated by the arrows and crossing each other along the broken lines. In deep water these are waves of oscillation, but when they reach the shallow water on the beach they become waves of translation and interfere with each other where they converge upon the shore. The tendency is for them to check each other along these lines of interference and to heap up the sands at the points marked A, where they strike the beach. At the points marked B the waves diverge

and throw the beach sands and all floating material alternately right and left.

In the diagram the waves are represented as being equal distances apart, the shore has a regular curve and the cusps are

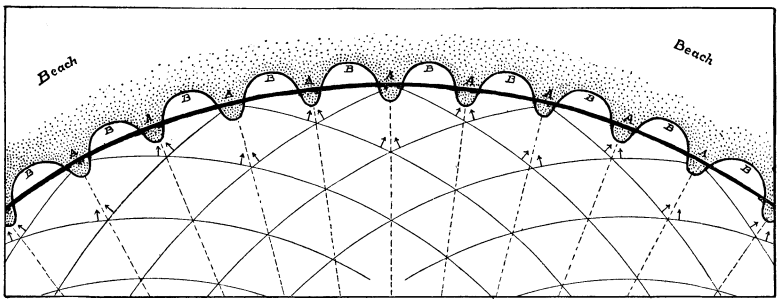

FIG. 1.—Diagram illustrating the formation of beach cusps. The concentric lines represent two sets of wave crests. The heavy line is the curve of a beach which, with these waves, would yield cusps of uniform size.

uniformly spaced. Such regularity is not to be expected in nature. The waves are not so evenly spaced, the depth of the water varies near the shore, and the waves do not all strike the shore at the same angle.

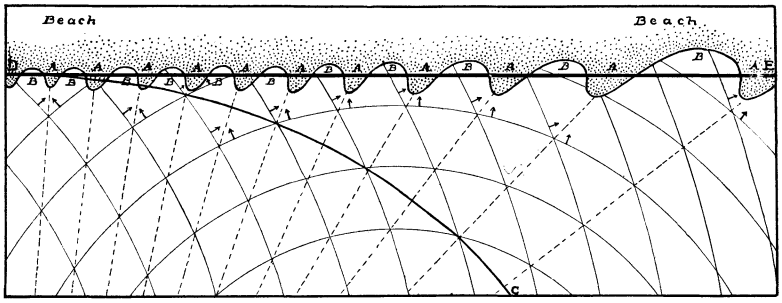

FIG. 2.—Diagram illustrating the formation of cusps of different sizes upon a straight beach D E. If D C were the beach line, these waves would produce cusps of uniform size.

In Fig. 2 the waves are represented as breaking upon a straight beach. If the water off shore were of a uniform depth and the waves were evenly spaced the cusps in this case would, for obvious reasons, be further and further apart from left to

right, as shown along the beach D E. The distance between the cusps is equal to the spaces, measured on the beach, between the radii along which the wave interference approaches the shore.

It is noticeable in California that the cusps are not permanent features of a given beach, but that they are sometimes very pronounced, at others but feebly developed, and at still others altogether obliterated or scarcely perceptible. The accompanying illustration (Fig. 3) is made from a photograph taken by the

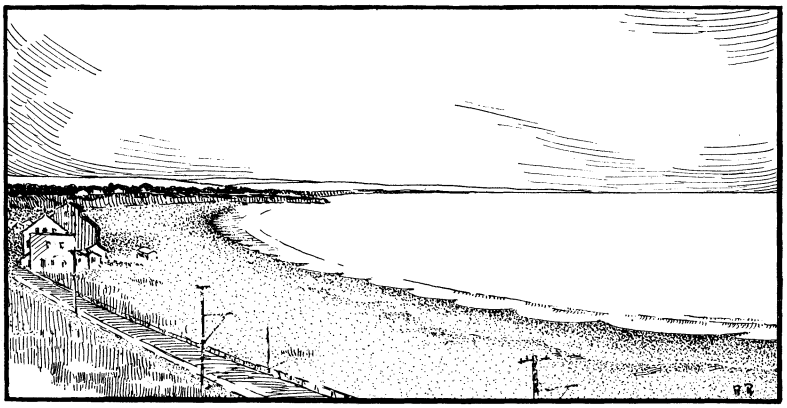

FIG. 3.—Cusps on the beach at Santa Cruz, Cal. From a photograph taken from the Sea Beach Hotel, June 14, 1900.

writer June 14, 1900, from the Sea Beach Hotel at Santa Cruz. These particular cusps were 60, 69, 78, and 81 feet apart. They are not always visible on that beach, however. The beach of Half Moon Bay, twenty-five miles south of San Francisco, is sometimes perfectly smooth and sometimes beautifully notched. These variations are due to the changes of the relations of the waves to each other, and of the relations of the radii of the points of interference to the beach (if there are still two sets of waves). It is evident that a variation in the depth of the water off shore would retard or hasten the advance of the waves, and would consequently produce a variation in the direction of these radii and of the distance between the cusps on the beach.

On the northeast coast of Brazil I have observed cusps of remarkable height. These were, however, invariably where the water off shore was deeper and the waves broke with more than usual violence upon the beach.

I am not sure that I know how the two sets of waves referred to in this hypothesis are produced, but I am confident that they do sometimes exist, for I have seen them. It seems possible that they may be formed by an abrupt change of the wind. The concentric form is given them by their entering a bay around a headland. In one case the waves entering a broad-mouthed bay seemed to make two sets on shore by breaking around an island in the middle of the bay's mouth. It is evident that the mathematics of the work of two sets of waves might be considerably enlarged upon, but this is sufficient to call attention to the subject. That seaweeds have nothing to do with the matter is shown by the fact that at several of the places where these phenomena occur there are no seaweeds or other "drift" on the beach.

J. C. BRANNER.

STANFORD UNIVERSITY, CALIFORNIA,
August 10, 1900.